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García Muñiz, Ana Salomé; Morillas, Antonio; Ramos Carvajal, Carmen

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KEY SECTORS

A NEW PROPOSAL FROM THE NETWORK THEORY

ANA SALOMÉ GARCÍA MUÑIZ [1]

Faculty of Economics. Department Applied Economics. University of Oviedo

Avd. Cristo s/n. Oviedo. Spain. E-mail: asgarcia@uniovi.es

ANTONIO MORILLAS RAYA

Faculty of Economics. Department of Statistics and Econometrics.University of Málaga

Campus El Ejido. Málaga. Spain. E-mail: morillas@uma.es

CARMEN RAMOS CARVAJAL

Faculty of Economics. Department Applied Economics. University of Oviedo

Avd. Cristo s/n. Oviedo. Spain. E-mail: cramos@uniovi.es

[1] Ana Salomé García Muñiz. University of Oviedo. Faculty of Economics. Department Applied Economics. Avd. Cristo s/n, 33071 Oviedo, Asturias (Spain). Telf. (+34) 985105058 Fax: 985105050 E-mail: asgarcia@uniovi.es.

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Ana Salomé García Muñiz (asgarcia@uniovi.es)

Antonio Morillas Raya (morillas@uma.es)

Carmen Ramos Carvajal (cramos@uniovi.es)

ABSTRACT

There is a long tradition of studies in the input-output field for determining key sectors. Their analysis allows the identification of those sectors with great effect on the demand and supply system and therefore, they constitute the basis for the growth and development of a territory.

In order to pinpoint, those sectors whose position is more relevant in the economy, we propose from the Network Theory a definition of centrality measures that we consider to be new in the input-output field. The definition is based on the consideration of three complementary characteristics: total effects, mediative effects and immediate effects. These measures we call multilevel indicators and they have the enormous advantage of allowing different-sized structures to be compared and the key sector concept to be approached from a relational and global viewpoint.

Key words: Network theory, input-output analysis, key sectors.

JEL Classification: C67, D57

SECTORES CLAVE

UNA NUEVA PROPUESTA A PARTIR DE LA TEORÍA DE REDES

Ana Salomé García Muñiz (asgarcia@uniovi.es)

Antonio Morillas Raya (morillas@uma.es)

Carmen Ramos Carvajal (cramos@uniovi.es)

RESUMEN

La determinación de los denominados sectores clave ha suscitado una larga tradición en el análisis input-output. Su análisis permite identificar aquellas ramas que poseen un alto efecto multiplicador en la demanda y la oferta del sistema y que, por tanto, suponen los pilares del crecimiento y desarrollo de una región o nación.

Para detectar aquellos sectores con una posición más relevante dentro de la economía proponemos a partir de la Teoría de Redes la definición de medidas de centralidad que consideramos nuevas en el ámbito input-output. Su definición está basada en la consideración de tres características complementarias: efectos totales, efectos inmediatos y efectos de intermediación. Estas medidas, que denominaremos de forma genérica indicadores multinivel, poseen la ventaja de permitir la comparación entre estructuras de distinto tamaño y ofrecer una aproximación desde un punto de vista relacional y global al concepto de sector clave.

Palabras clave: Teoría de redes, análisis input-output, sectores clave.

Clasificación JEL: C67, D57

KEY SECTORS. A NEW PROPOSAL FROM THE NETWORK THEORY

1. INTRODUCTION

The determination of key sectors has generated a long tradition in input-output analysis. Their study allows us to identify those sectors that have a high multiplier effect on the demand and supply system and, therefore, they constitute the pillars on which the growth and development of a country rest. Furthermore, the definition and evaluation of key sectors are still a focus of research and discussion. In the 1970s, the meaning of key sector has been the subject of debate and several adapted forms were put forward. The use of weighting factors and indexes with dispersion (Diamond, 1974; Boucher, 1976; Laumas, 1975a, 1975b, 1976; McGilvary, 1977), aggregation problems (Jones, 1976, Hewings, 1974), inconclusive evidence of the importance of key sector in development policy and growth (Yotopoulos and Nugent, 1973; Jones, 1976; Hewings et al., 1984; Clements and Rossi, 1991) or the measurement of forward linkages (Augstinovics, 1970; Cella, 1984; Oosterhaven, 1988; Dietzenbacher, 1997) are some of these subjects, among others.

Since the pioneering work of Chenery & Watanabe (1958), Rasmussen (1956) and Hirschman (1958) on the use of linkages to compare productive structures, several alternative means have been formulated for identifying key sectors. They include among others the use of triangularization (Aujac, 1960; Simpson and Tsukui, 1965, Fukui, 1986), the use of the Leontief output inverse (Augustinovics, 1970; Jones, 1976; Beyers, 1976), the so-called hypothetical extraction method (Strassert, 1968; Dietzenbacher, 1997), the measure of total linkage (Cella, 1984), the fields of influence (Hewings et al., 1988) or the multivariate approach (Csamanski, 1974; Díaz, Moniche and Morillas, 2006)[i].

Analogy, many researchers have applied Graph Theory and Network Theory in this frame. The development of these techniques in different fields of the economy has raised interest in the last decades. Since the pioneering papers of Ponsard (1969), Lantner (1974), Campbell (1975) and Rossier (1980) in input-output field, the extension of these theories has entailed a fresh approach in the study of the complex structures associated to the sectoral interactions. From graph and network theoretic concepts a large variety measures has arisen for facilitate a scan of the economic structure (Holub, Schnabl and Tappeiner, 1985; Ghosh and Roy, 1998; Lantner, 2001; Morillas, 1983; Aroche-Reyes, 1996, 2002 and 2003, among others). In regional science, other researchers as Kilkenny and Nalbarte (2002) have employed the Social Network analysis approach in the identification of the called Keystone Sector: *"critical entities in the community without which the community is fundamentally and detrimentally altered"*.

Generally, many Graph Theory theorems and applications are focused on boolean structures (Harary, Norman and Cartwright, 1965). When applied in an input-output context, these Graph-Theory applications convert the transaction matrix into a boolean structure. This is done by replacing the value of each coefficient that links one sector i with other sector j by a boolean coefficient. Thereby some information is lost because all values under the filter are set to zero and all values equal or above the filter are set to one. In theory, it is possible to change the value of the filter to explore all feasible sets. But there is an infinite number of potential values for the filter and extra computations needed to find the more correct filter value. So the boolean methods lead to lost of information and to a larger volume of computation than do quantitative methods (de Mesnard, 1995; de Mesnard, 2001). In order to overcome these criticisms, quantitative matrices and valued graphs are required (Lantner, 1972, 1974, 2001; Lantner and Carluer, 2004).

In this paper, from the Network Theory and Graph Theory we propose a new approach to the key sector determination. Focussing on the Social Network Theory, it is possible to study in depth articulation in production through the determination of key sectors in the diffusion of economic influence by considering three complementary features: the total effects exerted on the economy, the immediacy – a more or less direct tie- by which the sector connects with the others and its importance as a factor in transmitting effects throughout the network. In this sense, the approach adopted here draws not only on the study of the size of the linkages but the number of connections and the paths between sectors. In input-output framework, there is a body literature dealing with this question of structural complexity and lengths of chains (Robinson and Markandya, 1973; Hewings et al., 1984; Dietzenbacher and Romero, 2005). In this work, following the Friedkin (1991) research line on opinion formation in a group, we propose three new centrality[ii] measures in the input-output field to discover those sectors more relevant to the economy[iii]: total effects, immediate effects and mediative effects. From generalising of the theoretical frame we derive also an influence index of each sector in the network.

These measures we call multilevel indicators are complementary and provide a complete view of the sector´s position in the economic structure. Not only do they distinguish the sectoral economic impacts as other type of more traditional scopes but also the immediacy of their influences and the contribution of a sector as a conduit of other sectors´ effects. A new approach that overcomes some of the limitations of traditional Graph Theory applications around the use of dichotomy graphs. In this sense, these measures are built from the same theoretical frame derived from a valued graph associated with the input-output table and therefore the total available information volume can be used, unlike other habitual graph techniques in the input-output field.

2. STATISTICAL INFORMATION

The information used as a starting point is supplied by the input-output tables of Spain (SIOT-95) and the European Union (EUIOT-95) in 1995, because this is the most recently published data at European level.

The Spanish table of 1995 is not directly comparable with the European as it is assessed on basic prices and its aggregation is different from the European table. Therefore, a homogenisation process has been carried out.

The Spanish table of 1995 has 71 activity branches according to the NACE-93 for activities (National Classification of Economic Activities) and CPA-96 for products (National Classification of Products by Activities), whereas the European table is desegregated down to 25 branches of NACE-CLIO/R25. From the initial classification of the Spanish table we have established its correspondence with the 25 European sectors[iv]. In addition, we have made some accounting adjustments to achieve the homogeneity of the tables because the SIOT-95 is assessed on basic prices. Specifically we have added the net taxation on products. Given that there is only a taxation vector and no detailed matrix of interchanges, we have made a proportional distribution of them with respect to production, although we are aware it is an approximation and not the exact tax distribution.

3. METHODOLOGY

The development and application of what we label multilevel indicators in the input-output field focuses on industrial relations via three complementary effects and influence index thus extending the traditional viewpoint of polarised growth sectors. The choice of this label is due to the threefold level of the proposed analysis of key sectors and supposes a generic label that gathers the three effects. So that, the total effects determine the relative total impact of the sector on the rest of the economy, the immediate effects show the immediacy of the total effects implementation and the meditative effects indicate the importance of certain sectors as transmission links of total effects produced by others. Their construction and generalization though the influence index is presented below.

3.1. TOTAL EFFECTS

The mentioned effects are determined from a Markovian Matrix $\tilde{\mathbf{A}} = \{\tilde{a}_{ij}\}$ in which the relations between network nodes such $\tilde{\mathbf{A}} \geq \mathbf{0}$ are collected and each of its rows sum to unity:

$$\sum_{j=1}^{n} \tilde{a}_{ij} = 1, \forall i = 1, \ldots, n \qquad (1)$$

So we have a Markov Chain of n states where the matrix $\tilde{\mathbf{A}}$ gathers the transaction probabilities of one node to another. In this sense, the Markov Chain can be interpreted as a random walk for the weighted graph of the normalized coefficients stochastic matrix $\tilde{\mathbf{A}} = \{\tilde{a}_{ij}\}$ where the weight $\tilde{a}_{ij}$ is attributed to the arc between the node *i*th and *j*th of the valued graph.

As has been pointed out previously, the theoretical outline for the group opinion formation was development by Friedkin (1991). In this study it is indicated that initial opinions of individuals $y^{(1)}$ are transformed into final opinions $y^{(t+1)}$ through a process that reflects the tendency to social (α) and interpersonal $(\tilde{a}_{ij})$ influences. This process can be represented by means of the next equation:

$$y_i^{(t+1)} = \alpha\left(\tilde{a}_{i1} y_1^{(t)} + \ldots + \tilde{a}_{in} y_n^{(t)}\right) + (1-\alpha) y_i^{(1)} \qquad (2)$$
$$0 < \alpha < 1$$

or in matricial terms as:

$$\mathbf{y}^{(t+1)} = \alpha\tilde{\mathbf{A}}\mathbf{y}^{(t)} + (1-\alpha)\mathbf{y}^{1} \tag{3}$$

If certain conditions are verified (Friedkin, 1990), the initial opinions are transformed into an equilibrium solution, in other words, a final stationary opinion:

$$\mathbf{y}^{\infty} = \left(\mathbf{I} - \alpha\tilde{\mathbf{A}}\right)^{-1}(1-\alpha)\mathbf{y}^{1} = \mathbf{V}\mathbf{y}^{1} \tag{4}$$

where $\mathbf{V} = \left(\mathbf{I} - \alpha\tilde{\mathbf{A}}\right)^{-1}(1-\alpha)$ gathers the effects generated between network nodes.

In general terms, this process of opinion formation can be related to the mechanism by which the necessary production for satisfying a final demand increase is determined exogenously. The production will be the equilibrium solution established from the final demand and the sectoral influences.

If the initial outline is developed in an input-output frame, the expression can be derived:

$$x_i = \alpha\left(\tilde{a}_{i1}x_1 + \ldots + \tilde{a}_{in}x_n\right) + (1-\alpha)d_i \tag{5}$$

where x_i and d_i represent the production and demand of sector *i*th respectively, α offers a weighting that allows the effect of exogenous changes in the demand to be calibrated and the consequent sectoral transactions weight and $\tilde{a}_{ij}$ represents the normalized input-output coefficients which can be calculated as the proportion of sector *j*th purchases to sector *i*th (a_{ij}) in terms of direct production effect of the last sector $\left(\sum_{j=1}^{n} a_{ij}\right)$.

So in this work the classical technical coefficients are not employed but a modification of them is used. The modification lies in the division of each coefficient by the row total, showing the percent of total intermediate input that sector j needs from sector i. The required probabilities for the technique are obtained. In this sense, $\tilde{a}_{ij}$ takes values between zero and one and the sum of row is equal to unity. Therefore we would have normalized coefficients for rows, it is, net indicators of the relevance of each relation or coefficient $\tilde{a}_{ij}$ over its total.

The different weight attributed by the weighting α to the final and intermediate demand allows the study of the influence that is supposed by exogenous changes and/or relations between sectors for the reference sector. This is of interest in development and economic policy decision-making.

Given the model expression, the determination of total effects will be basically related to the number and length of the paths between sectors through the productive relation, so[v]:

$$\mathbf{V} = \left(\mathbf{I} - \alpha\tilde{\mathbf{A}}\right)^{-1}(1-\alpha) = \left(\mathbf{I} + \alpha\tilde{\mathbf{A}} + \alpha^2\tilde{\mathbf{A}}^2 + \alpha^3\tilde{\mathbf{A}}^3 + \ldots\right)(1-\alpha) \qquad (6)$$
$$0 < \alpha < 1$$

where α is a sectorial relations weighting that allows the influence capacity between sectors to be calibrated and $\tilde{\mathbf{A}}$ represents the normalized input-output coefficients matrix. The method exploits the power-series version where each round (power of $\tilde{\mathbf{A}}$) is considered to represent a production round. As other methodologies (Yan and Ames, 1965; Robinson and Markandya, 1973; Hewings et al., 1984) we can consider the number of rounds its takes for a level of final demand to be satisfied as an indicator of the structural complexity.

It can be seen the matrix **V** is determined by the inverse Leontief matrix weighting for the said coefficient α. The increase of steps number by which two sectors can be connected suppose a decrease of transactions impact whereas for similar distances the effect depends on the strengths of the relations $\left(\alpha\tilde{a}_{ij}\right)$. Both features are considered in the propose specification. So, "*in short, the total effect of one actor on* *another is a weighted sum of the number of different channels that join them in the network, where each channel is weighted according to its length and the strength of constituent links*" (Friedkin, 1991).

Friedkin and Johnsen (1990) demonstrate that, under the hypothesis $\lim_{k\to\infty}\tilde{\mathbf{A}}^k = \tilde{\mathbf{A}}^\infty$, in the case that α approaches one:

$$\mathbf{V} = \lim_{\alpha\to 1^-}\left(\mathbf{I}-\alpha\tilde{\mathbf{A}}\right)^{-1}(1-\alpha) = \tilde{\mathbf{A}}^\infty = \mathbf{W} \tag{7}$$

So if α approaches to one, **V** may converge to **W**, under certain conditions of matrix $\tilde{\mathbf{A}}$. Then the matrix **V** approaches to the limit of $\tilde{\mathbf{A}}$ $\left(\lim_{k\to\infty}\tilde{\mathbf{A}}^k\right) = \mathbf{W}$ in which the total effect is constant for each sector *i*th. Therefore, the matrix **W** takes the form of a stationary state:

$$\mathbf{W} = \begin{bmatrix} w_1 & \dots & w_n \\ \dots & \dots & \dots \\ w_1 & \dots & w_n \end{bmatrix} \tag{8}$$

We can affirm stochastic matrix $\tilde{\mathbf{A}}$ of spectral radius equal to one is a convergent matrix whose limit will be non-null $\left(\lim_{k\to\infty}\tilde{\mathbf{A}}^k \neq 0\right)$, so the assumption is made matrix converges $\mathbf{V} = \mathbf{W}$ under the hypothesis of $\alpha \to 1^-$.

In the absence of additional information about weighting value α, this hypothesis will be employed in the total effect calculus so that the total effect for a sector *j*th $TEC_{(j)}$ is defined as:

$$TEC_{(j)} = \frac{\sum_{i=1}^{n} v_{ij}}{n} = \frac{\sum_{i=1}^{n} w_{ij}}{n} = w_j \quad \forall j \tag{9}$$

this can be expressed alternatively from a (nx1) vector t:

$$\mathbf{t} = \mathbf{V}'\boldsymbol{\Phi} \tag{10}$$

where $\mathbf{\Phi} = \left\{\frac{1}{n}\right\}$ is a (nx1) vector and $\mathbf{V}'$ the transposed matrix of $\mathbf{V}$. It is an average of the column elements of matrix $\mathbf{V}$ so that, the total effect of sector *j*th with respect to the whole economy will be more relevant depending on the size of this value.

See the analogy between the classical scope of relevant relations in the input-output model and our total effects indicator based on the Social Network Theory[vi]. From the Leontief model, the classical Rasmussen coefficients (1956) use the normalized columns sum of the inverse Leontief matrix to measure the pulled effect over the economy. The total effects indicator employs the columns sum of the called revised inverse Leontief matrix $\left(\mathbf{V} = \left(\mathbf{I} - \alpha\tilde{\mathbf{A}}\right)^{-1}(1-\alpha)\right)$. So we can consider the Rasmussen coefficients a particular case where the influence coefficient matrix α has not been specified. Likewise the Ghosh model, Augustinovics (1970) determines the forward linkages from the rows sum of the inverse distribution matrix. The distribution coefficients consideration would allow the derivation of the total effects indicator in the same way.

3.2. IMMEDIATE EFFECTS

The analysis of immediacy –no mediation- is an important feature in economic policy evaluation. The sectors which effects are basically transmitted over lengthy sequences of economic relations, have less economic impact than those ones with a high number of direct linkages. Not only their multipliers would be smaller (Lantner, 1974; Morillas, 1983) but they have lower possibilities of transmission of innovation procedures (García, Morillas and Ramos, 2005). This characteristic can be determined from the so-called immediate effects that are quantified from the Markov Chain associated to the matrix $\tilde{\mathbf{A}}$.

In this sense, the Markov Chain can be interpreted as a random walk for the weighted graph of the normalized input-output coefficients stochastic matrix $\tilde{\mathbf{A}} = \{\tilde{a}_{ij}\}$ where the weight $\tilde{a}_{ij}$ is attributed to the arc between the sectors *i*th and *j*th of the valued graph.

Then we have a Markov Chain of n states where the matrix $\tilde{\mathbf{A}}$ gathers the transaction probabilities of one sector to another, so that the element (i,j) of the called transaction matrix of the k step, $\tilde{\mathbf{A}}^k$, will show the probability of passing from the sector *i*th to *j*th in k steps exactly. From this stochastic process, the immediacy of sector *j*th effects in the network can be determined by the length of economic transactions sequences weighting for the relations strength (Kemeny and Snell, 1960):

$$\mathbf{M} = \left(\mathbf{I} - \mathbf{Z} + \mathbf{E}\hat{\mathbf{z}}_{\mathbf{dg}}\right)\hat{\mathbf{q}} \qquad (11)$$

where $\hat{\mathbf{q}}$ is a diagonal matrix with elements $q_{ii} = \frac{1}{w_i}$, **E** represents a (nxn) matrix formed by ones and **Z** is the so-called fundamental matrix whose expression is:

$$\mathbf{Z} = \left(\mathbf{I} - \tilde{\mathbf{A}} + \tilde{\mathbf{A}}^{\infty}\right)^{-1} \qquad (12)$$

so that $\mathbf{A}^{\infty}$ will coincide with the matrix **W** that collects the process stationary state (w_1,..., w_n) and $\hat{\mathbf{z}}_{dg}$ is a diagonal matrix built from the **Z** definition. Thus, m_{ij} gathers the average length of the sequences of relations from sector j to sector i –each sequence weighted according to the strength of its constituent links-.

The immediacy with which the sector is connected with others and expands its total effects is expressed in the respective columns of matrix **M**. So, immediate effects (IEC) are defined as the reciprocal of the mean length of the sequences of relations from sector *j*th to others (Friedkin, 1991):

$$IEC_{(j)} = \left(\frac{\sum_{i=1}^{n} m_{ij}}{n} \right)^{-1} \quad \forall j \qquad (13)$$

where m_{ij} are the elements of matrix **M**, or in matricial terms as:

$$\mathbf{r} = n\boldsymbol{\gamma} \qquad (14)$$

where $\boldsymbol{\gamma} = \{\gamma_j\} = \left\{ \frac{1}{\sum_{i=1}^{n} m_{ij}} \right\}$ is a $(nx1)$ vector.

This indicator takes into account the lengths and strengths of the sequences of productive relations. The larger the IEC, the more widely the total effects of a sector tend to extend and so the branch is less dependent on intervening sectors.

3.3. MEDIATIVE EFFECTS

The mediative effects refer to the importance of certain sectors as instruments of total effects transmission. The basic assumption of this measure is that sectors involved in many of the paths linking other sectors can affect the relations that occur along these paths. These sectors facilitate the function and economic inter-connexion, so that they support the inter-relation between different productive activities. Such economic agents work like crossroads in the system and constitute key points for the whole development of the economy. So that those sectors that inter-relate regularly by the connecting elements could form industrial complexes and be set up together in the space.

The classical Streit coefficients (Streit, 1969) in the input-output analysis present a similar interpretation. Their determination from intermediate consumption matrix allows identifying the fundamental sectors in the connexion of the economy functioning given the importance of their role as being demanded by other sector products or as suppliers of needed intermediate inputs in the production of other sectors. So the classical method and the proposed technique in this paper have a common objective although the mathematical approach differs noticeably. The mediative effects present a more complete study than the analysis offered by the classical methodology due to the consideration of direct and un-direct relations between sectors. So it is a richer indicator for the linkages of productive transactions.

For their estimation, the mean length of the sequences of productive relations - the previous matrix **M**- can be decomposed in the number of steps from sector *j*th to sector *i*th via other intermediate sectors:

$$m_{ij} = \sum_{k=1}^{n} t_{(j)ik} \quad i \neq j \neq k \tag{15}$$

where $t_{(j)ik}$ is the *ik*th entry in the matrix **T** in:

$$\mathbf{T}_{(j)} = \left(\mathbf{I} - \tilde{\mathbf{A}}_{(j)}\right)^{-1} \tag{16}$$

and $\tilde{\mathbf{A}}_{(j)}$ is the matrix obtained by deleting the *j*th row and column of the matrix $\tilde{\mathbf{A}}$ (Kemeny y Snell, 1960).

So the mediative effects indicate the importance of *j*th sector as a transmitter or crossroad point for the economic network connexion and from these equations they are calculated as:

$$MEC_{(j)} = \frac{\sum_{k=1}^{n} \bar{t}_{(k)j}}{n} \tag{17}$$

where,

$$\bar{t}_{(k)j} = \frac{\sum_{i=1}^{n} t_{(k)ij}}{(n-1)t_{(k)jj}} \quad i \neq j \tag{18}$$

gathers the contribution of sector *j*th in the transmission of the effects of sector *k*th.

Matricial the mediative effects can be expressed from the matrix $\overline{\mathbf{T}} = \left\{\overline{t}_{(k)j}\right\}$ definition:

$$\mathbf{c} = \overline{\mathbf{T}}\mathbf{\Phi} \tag{19}$$

where $\mathbf{\Phi}$ is a (nx1) vector whose elements are $\frac{1}{n}$.

3.4. INFLUENCE INDEX

The present measures –total effects, immediate effects and intermediate effects- refer jointly to three important and complementary structural features where the sectorial influence weighting plays a relevant role.

In the case of the absence additional information, the applied assumption is a coefficient α whose value is equal for all sectors and near to unit $\left(\alpha \to 1^-\right)$. However, we consider this hypothesis excessively restrictive in the input-output frame where the exogenous changes in the network would affect each sector differently. The existence of a different coefficient for each sector seems a reasonable assumption in an economic universe where the agents have very different powers or degrees of influence and the final and intermediate demand weight can have unequal dominance in sectorial production necessities induced by variations in the final demand. This analysis would allow the differentiation of coefficients between sectors (α_i) with the aim of distinguishing the sector propensity to sectorial influences. The determination of this value that we call the influence index allows us to know the influence capacity generated by the sectors in the input-output table.

Under this new assumption, the model is specified as:

$$x_i = \alpha_i\left(\tilde{a}_{i1}x_1 + \ldots + \tilde{a}_{in}x_n\right) + \left(1-\alpha_i\right)d_i \tag{20}$$

expressed matricially:

$$\mathbf{x} = \hat{\mathbf{s}}\tilde{\mathbf{A}}\mathbf{x} + (\mathbf{I} - \hat{\mathbf{s}})\mathbf{d} \tag{21}$$

where $\hat{\mathbf{s}}$ is a diagonal (nxn) matrix that gathers the influence coefficients for each sector:

$$\hat{\mathbf{s}} = \begin{pmatrix} \alpha_1 & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ 0 & 0 & \dots & \alpha_n \end{pmatrix} \tag{22}$$

$\tilde{\mathbf{A}} = \{\tilde{a}_{ij}\}$ is a (nxn) matrix that represents the normalized inter-sectoral coefficients and $\mathbf{x} = \{x_i\}$ and $\mathbf{d} = \{d_i\}$ are (nx1) vectors that collect the production and final demands of sector *i*th, respectively.

The determination of the output level is established from the equivalence between this specification with the demand model of Leontief:

$$x_i = (a_{i1}x_1 + \dots + a_{in}x_n) + d_i \tag{23}$$

or in terms of matrixes :

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{d} \tag{24}$$

We verify in the theoretical frame derived from the Friedkin (1991) study the condition fulfilment expressed in the demand model wherein the necessary production levels to satisfy an exogenous final demand objective are determined:

$$\hat{\mathbf{s}}\tilde{\mathbf{A}}\mathbf{x} + (\mathbf{I} - \hat{\mathbf{s}})\mathbf{d} = \mathbf{A}\mathbf{x} + \mathbf{d} \tag{25}$$

Operating properly:

$$\hat{\mathbf{s}}(\tilde{\mathbf{A}}\mathbf{x} - \mathbf{d}) = \mathbf{A}\mathbf{x} \tag{26}$$

and given that the final demand can be established as $\mathbf{d} = \mathbf{x} - \mathbf{A}\mathbf{x}$, then:

$$\hat{\mathbf{s}}(\tilde{\mathbf{A}} + \mathbf{A} - \mathbf{I})\mathbf{x} = \mathbf{A}\mathbf{x} \tag{27}$$

However, we consider more suitable not to consider the auto-consumption of sectors as an integrant part of the degree of sectoral influence. On the contrary, an autarky sector would show some power degree over the rest of the sectors when this dominion is really null. This option is habitual in the applied works of graph theory (Harary et al., 1965; Wasserman and Faust, 1994) and in the qualitative input-output analysis (Morillas, 1983, Holub and Schnabl, 1985).There is nothing about interdependency –circularity- neither dependency –triangularity- in auto-consumption. This only is an autarky matter (Lantner, 1974), which is not relevant for analyzing influence relationships between sectors.

So if we eliminate the auto-consumptions, we can define the next equalities system:

$$\begin{pmatrix} \alpha_1\left[\left(a_{12}X_2+\ldots+a_{1n}X_n\right)+\left(\tilde{a}_{12}X_2+\ldots+\tilde{a}_{1n}X_n\right)\right] \\ \ldots \\ \alpha_n\left[\left(a_{n1}X_1+\ldots+a_{n(n-1)}X_{(n-1)}\right)+\left(\tilde{a}_{n1}X_1+\ldots+\tilde{a}_{n(n-1)}X_{(n-1)}\right)\right] \end{pmatrix} = \begin{pmatrix} a_{12}X_2+\ldots+a_{1n}X_n \\ \ldots \\ a_{n1}X_1+\ldots+a_{n(n-1)}X_{(n-1)} \end{pmatrix} \quad (28)$$

this determines a grouping equation represented by:

$$\alpha_i = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{n} a_{ij}X_j}{\sum_{\substack{j=1 \\ j\neq i}}^{n}\left(a_{ij}X_j+\tilde{a}_{ij}X_j\right)} \quad (29)$$

Given that the normalized technical coefficients are defined as $\tilde{a}_{ij} = \frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}}$, then the sectorial index influence can be established as:

$$\alpha_i = \frac{1}{1+\frac{1}{\sum_{j=1}^{n} a_{ij}}} \quad (30)$$

It is a measure related with the direct effects of sector *i*th $\left(\sum_{j=1}^{n} a_{ij}\right)$ on the rest of the productive sectors and allows the total effect generated for the sector to be recalibrated.

In this new scene, the total effects must be revised. Given the expression (21), it will obtain from a transformation series:

$$\mathbf{X} = \left(\mathbf{I} - \hat{\mathbf{s}}\tilde{\mathbf{A}}\right)^{-1}\left(\mathbf{I} - \hat{\mathbf{s}}\right)\mathbf{D} \tag{31}$$

where **V** now is:

$$\mathbf{V} = \left(\mathbf{I} - \hat{\mathbf{s}}\tilde{\mathbf{A}}\right)^{-1}\left(\mathbf{I} - \hat{\mathbf{s}}\right) \tag{32}$$

The revised total effects of sector *j*th will be defined then as:

$$TEC^{*}_{(j)} = \frac{\sum_{i=1}^{n} v_{ij}}{n} \quad \forall i, j \tag{33}$$

and will offer a more exact valuation of the impacts of the sectors in the network.

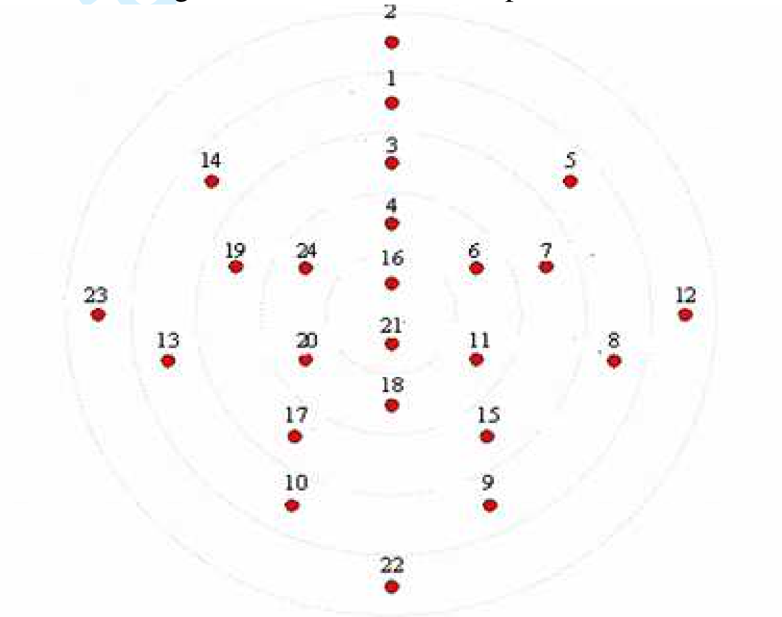
The multilevel indicators and this sectoral influence index will allow us to identify and characterize the sectors that work as crossroads in the economic system and constitute crucial connexion elements for economic structure performance. So the determination of those key sectors in economic influence diffusion is articulated around the total effects, the immediacy of these effects on other members of the network, the importance of transmitting elements in the exchange network and the propensity to generated impacts.

4. AN ANALYSIS OF EUROPEAN AND SPANISH ECONOMIES

In order to determine the key sectors in the Spanish and European networks we apply the multilevel indicators to the respective input-output tables both referring to 1995. The obtained results[vii] under the basic assumption of influence index next to the unit are shown in the tables nº 2 and nº 3 collected in the appendix. The study of this information is presented below from the individual graphic representation of the structural effects for each economy.

The first representations refer to the total effects that each sector has on the economy. The figure is formed by concentric circles so that the sectors which are nearer of the figure core will have higher effects. In this sense, we can observe that only Construction (16) and a limited group of traditional manufactures- Metal products except machinery (6), Non-metallic mineral products (4) -constitute the growth core of the Spanish economy.

Figure nº 1. Total Effects. Spain 1995

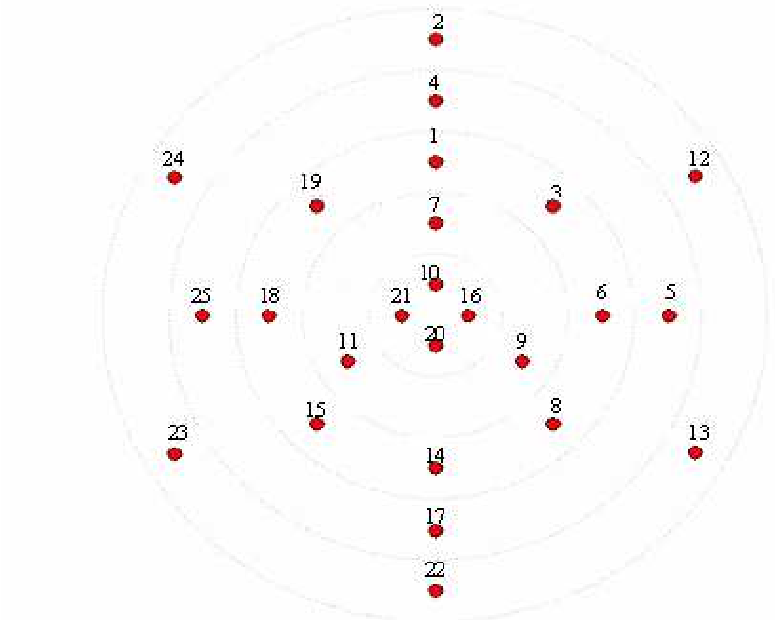


Source: Own elaboration from SIOT-95.

Together with these sectors, transport -Auxiliary transport services (21), Maritime and air transport services (20), Inland transport services (19)- Lodging and catering services (18), Food, beverages, tobacco (11), Recovery, repair services, wholesale, retail (17) and a series of sectors related to the transformation, fusion and production of metallurgic products -Ferrous and non-ferrous ores and metals (3), Agricultural and industrial machinery (7) and the already mentioned Non-metallic mineral products (4) and Metal products except machinery (6)- drive the Spanish economy. Their total effects on the economic structure are outstanding. So the industrial sector is fundamental to the Spanish economy as it is corroborate for other studies. Thus, Cañada (1994) points out that the Spanish industry has "*a potentiality of added value creation more than other sectors.* However, Spanish manufacture continues to show a traditional structure in the reference date 1995 of the input-output tables with a strong presence of medium-low technological intensity sectors - Recovery, repair services, wholesale, retail (17), Metal products except machinery (6) or Other manufacturing products (15), among other assets-. The peculiar characteristics of the iron and steel sector constitute a heritage of the economic policy developed in Spain from the thirties to the seventies of the last century. On the other hand, construction has been perhaps one of the most dynamic sectors in Spain during the growth era initiated in the middle of the 90's. This can be due to its direct influence on other activities because of great importance in intermediate consumptions in its production and its importance in the employ generation.

Contrary to the Spanish economy the European structure, gathered in the figure nº 2, reveals similarities but at the same time notable differences.

Figure nº 2. Total Effects. Europe 1995



Source: Own elaboration from EUIOT-95.

Building and construction (16) continues to present high total effects in the economy. In Europe this market is formed by very heterogeneous national situations. Nevertheless, in general form, construction has an important role in the conditions and capacity of growth of an economy since some of its components and infrastructures endowment are essential factors in the competitiveness of productive network.

However, the high and medium technological segments play an important role in the European economy. The importance of sectors such Transport equipment (10), Office and data processing machines (8), Electrical goods (9) and Agricultural and industrial machinery (7) show the outstanding participation of high-medium technological sectors in Europe in contrast to the more traditional Spanish structure. This feature is a possible sign of the backing for European technology. Furthermore, the different technological composition of Spanish and European manufactures has a decisive influence on the differing behaviours. The sectors with a larger technological content and with a certain weight in the European economy have shown a relatively minor development in Spain which limits their possible impact on the economic structure (Buesa, 1996). This centrality position is shared with Maritime and air transport services (20), Auxiliary transport services (21) and Food, beverages, tobacco (11) which are key in both economies and are some of the main sectors generating added valued for an economy (EUROSTAT, 1999)[viii].

So the industrial sector in spite of the known and debated de-industrialization[ix] period sustained in current societies, is shown as essential for the whole economic activity "*due to both backward and forward effects and decisive role in the generation, absorption and diffusion of all type of innovations*" (Velasco & Plaza, 2003).

The services sector represents also an important part in any post-industrial economy. Its importance in the European economies contributes decisively to wealth and employment (EUROSTAT, 1999). The greater role of services reflects a shift in consumer demand, which is linked to the high income elasticity of services, increased business demand as well as some outsourcing of manufacturing to specialised services.

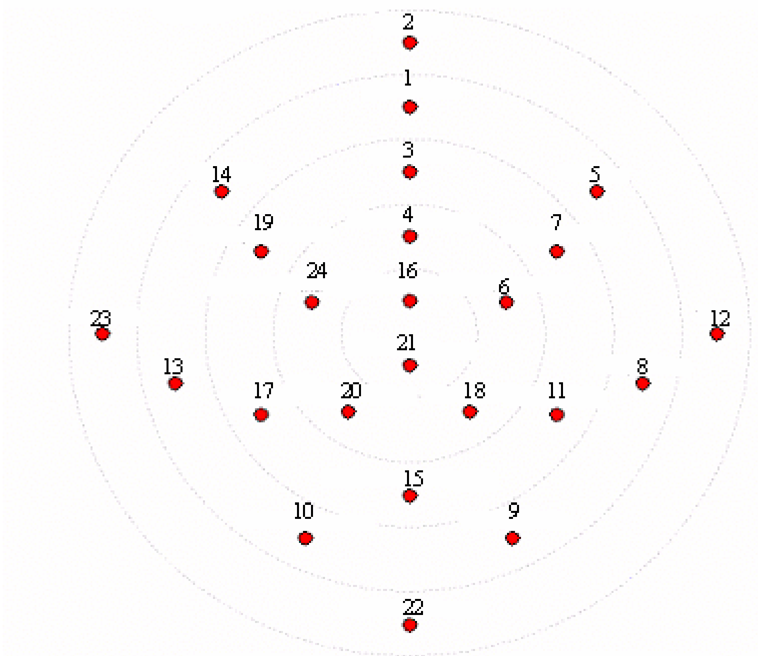
If complementary those sectors set under the first quartile as branches of little relevance, Fuel and power products (2), Textiles and clothing, leather, footwear (12), Communication services (22) and Services of credit, insurance institutions (23) will be common in both economies. Moreover Paper and printing products (13) and Other market services (24) show generally relatively small weight in the European countries.

The scarce relevance of energy is outstanding although it is an element that determines economic and social development. The fact that the European Union does not cover its energy necessities and must import more than half of its consumed energy (EUROSTAT, 1999), limits its possible impact on domestic economy.

The recent trends in other activities can suppose a barrier in the generation of impacts on the economies and their centrality position. Thus, for example, the European Union is a net importer of the Textiles and clothing, leather, footwear, a sector whose the contracting and restructuring tendencies have been strengthened from the recession suffered at the beginning of the nineties. Production has been moved to regions with low costs such as south and Southeast Asia or sub-contracted by East European business. Over the past decade the revolutions in information and communication technologies also have deeply transformed international commerce, social interaction, political relations and development issues. Today the role of electronic communications as a tool and conduit for promoting development and opportunity is increasingly indispensable. However, there are continuing gaps in access to ICT and to the opportunities that they can foster. So in spite of immense progress in expanding the reach of basic and new ICT services and applications, the differences still exist and new strategic approaches should be considered for making the benefits of these technologies more available. As well the financial services industry is facing up to the challenges of strong competition and the deep structural changes in the economic context that imply risk factors as in Latin American economies, the growth of high credits, the increase of residential properties or the growing competitive and dynamic environment of banking.

This distribution of the total effects impacts must be completed with a study on the propagation degree -immediate effects- and the transmitter role of certain sectors –mediative effects. The immediate effects for Spain and Europe are gathered graphically in figures nº 3 and nº 4 respectively, and show in general lines a sectorial schedule very similar to the total effects study. That is, those sectors with larger total effects enjoy a relatively quick access capacity to the rest of the economic agents. This feature allows them to transmit their influence efficiently to the rest of the economy.

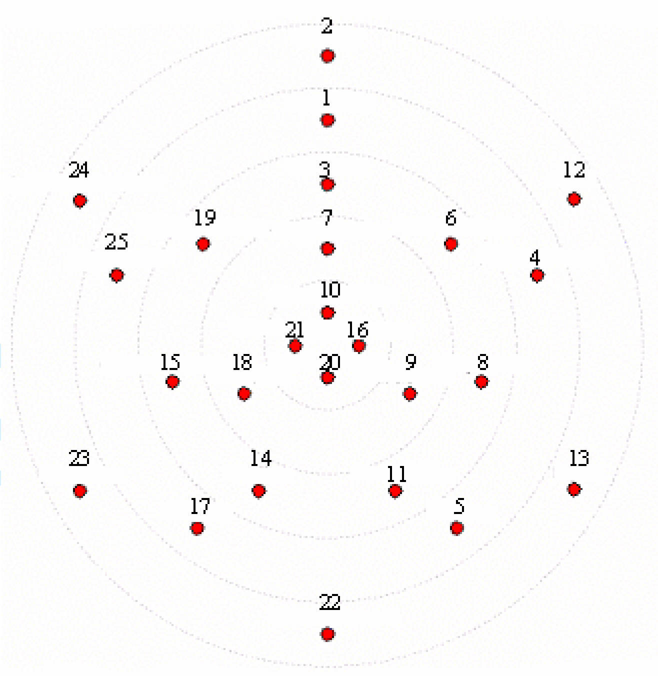
Figure nº 3. Immediate Effects. Spain 1995



Source: Own elaboration from SIOT-95.

Only the loss of position for Food, beverages, tobacco (11) is outstanding. So although this sector enjoys an important pull effect, it has not easy access or inmediacy to the all the productive branches available which can slow down its impact.

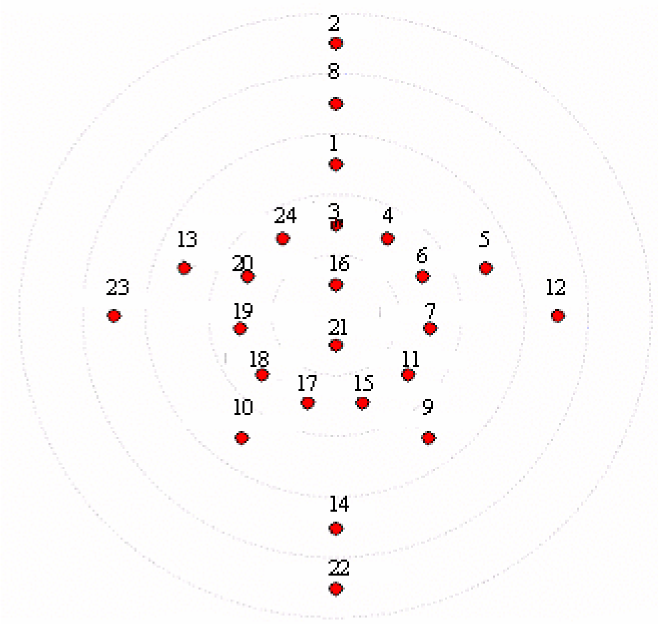
Figure nº 4. Immediate Effects. Europe 1995



Source: Own elaboration from UEIOT-95.

Finally figures nº 5 and nº 6 of the mediative effects identify the sectors that work in the economic system as cross roads and so constitute very important connexion elements for economic structure performance. It is at this point where most sectors delimit a compact framework of essential linkages for economic vertebration.

Figure n º 5. Mediative Effects. Spain 1995

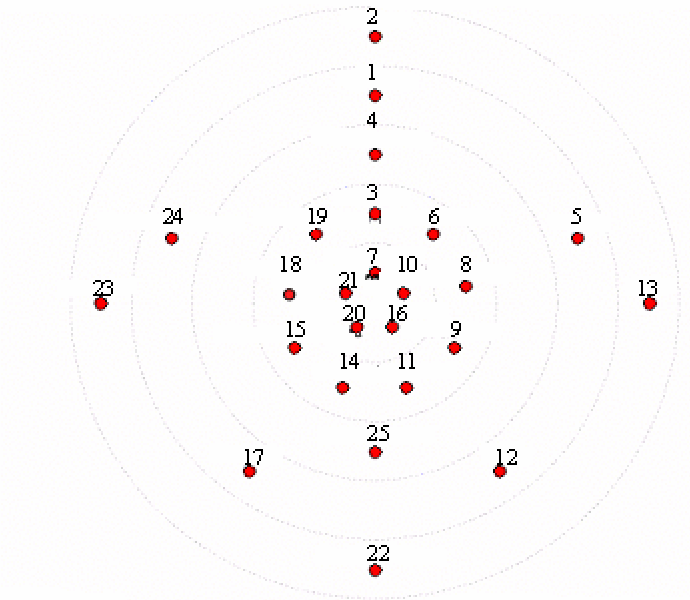


Source: Own elaboration from SIOT-95.

Spain shows an important and numerous core of key sectors in its economy under this focus. In contrast Europe shows a greater scaled intermediary section, built round a solid nucleus. So Building and construction (16), Auxiliary transport services (21), Agricultural and industrial machinery (7), Transport equipment (10) and Maritime and air transport services (20) are fundamental in sectoral vertebration.

Likewise, the better position of high technology sectors such as Office and data processing machines (8) and Electrical goods (9) are emphasized in Europe. In general, we can observe that construction, transport, food and certain manufactures related to equipment provide the fundamental connexion for structure performance. They tend to have strong relations with suppliers and customers.

Figure nº 6. Mediative Effects. Europe 1995



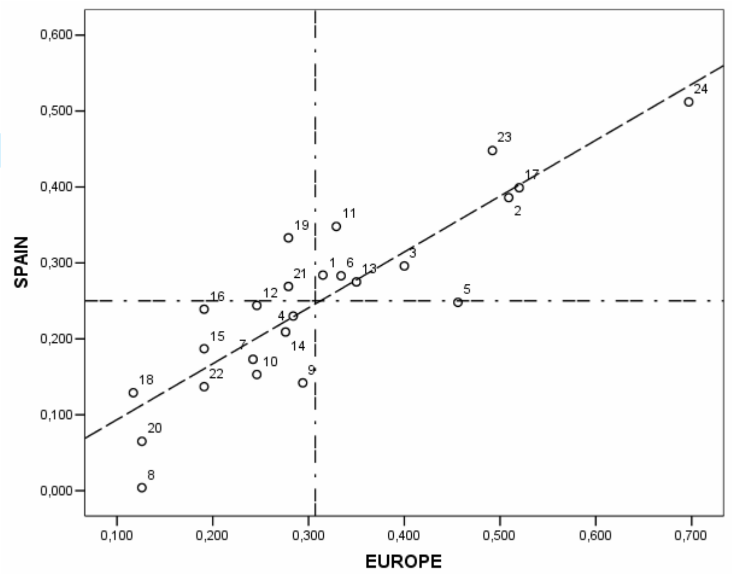
Source: Own elaboration from UEIOT-95.

The conditions of these markets are essential and must be the object of observation for the vertebration of the economy. In this sense, a strong, open and competitive transport sector can be a key instrument for retaining the economic activity and generating other new activities in a country that tends to import goods produced in third countries such as China and the Far East. In this context, planning and managing transport development policies, which could simultaneously satisfy transport needs, environmental concern and de-congestion of the main urban areas, is a challenging task. Or on other hand, the food sector must take into account the changes in demand for products of greater quality in production and presentation. The technological modernization is a crucial necessity in current societies.

In contrast, other sectors such as Energy (2), Communication services (22) and Services of credit, insurance institutions (23) are of scarce importance in connexions in both economic networks. Their low total effects and capacity of mediation limit their possible impacts seriously.

These effects until now have been calculated under the assumption of influence coefficient α whose value is equal for all sectors and tends to the unit $\left(\alpha \to 1^{-}\right)$. It is a hypothesis employed in scenarios in which there is not additional information. However, and as we have said before, we consider that this assumption is excessively restrictive in the input-output frame where the effect of exogenous changes in the network will affect sectors differently. The determination of a different influence index for each sector allows us to represent the dominance capacity generated in an input-output table. This weighting will affect consequently the total effects that a sector can produce on the rest and allow a better fit in the total impacts value. Table nº 4 in the appendix gathers the values of the influence index for the Spanish and European sectors which have been calculated according to the expression (30). In general lines, the influence degree of the different sectors is very similar between both economies as can been seen in figure nº 7 in which X and Y axes gather the influence index, respectively, and the reference lines are constituted around the mean influence indices of Europe and Spain. Many observations are located in the first and third quadrant of the figure, so that the majority of sectors has a high or low influence index –over or under the mean- in both economies. For example Other market services (24), Services of credit, insurance institutions (23), Recovery, repair services, wholesale, retail (17) and Fuel and power products (2) show a high influence degree. All of these sectors are greatly influenced by changes in their intermediate demand.

Figure nº 7. Sectoral influence index



Source: Own elaboration from SIOT-95 and EUIOT-95.

On the contrary, those sectors with a low influence level are orientated towardsthe final demand. If the considered level is of little relevance when it is under the mean, Office and data processing machines (8), Lodging and catering services (18), Maritime and air transport services (20) or Communication services (22), among others, will be within this category in both economies. As lightly different influence index is assessed in the transport sector (10, 19, 20, 21), high-medium technological sectors (5, 8, 9, 23) and construction (16). In this score, the European Union offers a strongly diversified scenario when looking among other factors at infrastructure capacities, access to main transport links, construction and civil engineering. Furthermore, the power of the high technological segment in Europe is a consequence of European policy.

The consideration of these influence indices offers a new evaluation of total effects collected in the appendix and shown graphically below. In the case of Europe, the revised effects are very similar to the initial impacts as it can be observed in figure nº 8. Only Textiles and clothing, leather, footwear (12), Paper and printing products (13), Communication services (22), Services of credit, insurance institutions (23) have greater total effects than the initial estimated impacts. In contrast, the sectors Maritime and air transport services (20) and Auxiliary transport services (21) now present fewer effects on the structure.

Figure nº 8. Total Effects Europe

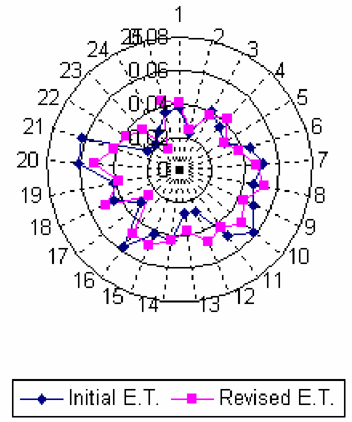
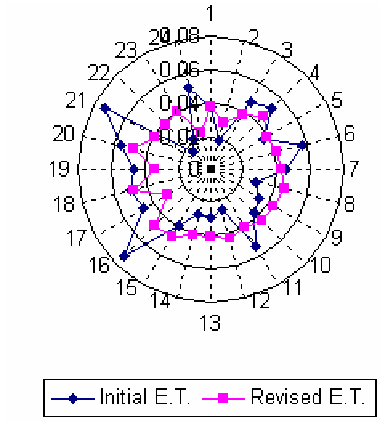


Figure nº 9. Total Effects Spain



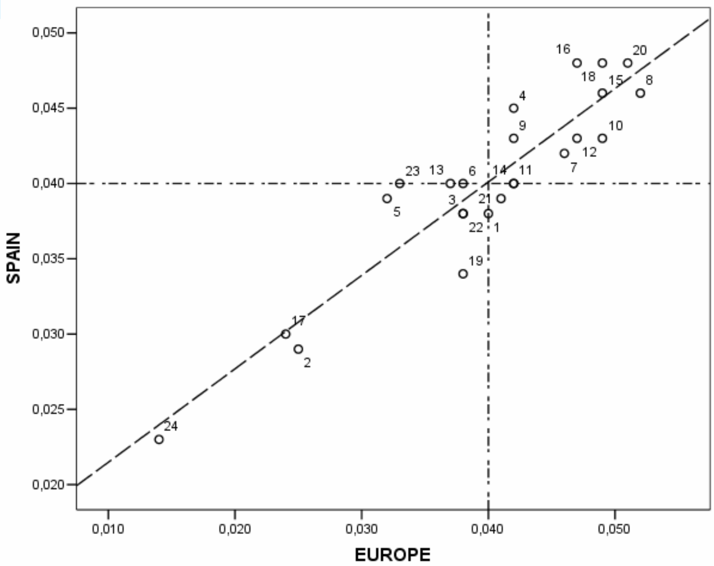
Source: Own elaboration from SIOT-95 and EUIOT-95.

In Spain the revised total effects are smaller in general except for the sectors Office and data processing machines (8), Electrical goods (9), Textiles and clothing, leather, footwear (12), Paper and printing products (13), Rubber and plastic products (14), Communications (22) and Services of credit, insurance institutions (23). All of them –except 12 and 13- are high-medium technological activities. This feature supposes a better performance of the Spanish high technological segment and a coming together of the positions of the two economies.

In fact, both network economies present great similarities in their performance if a variable influence index is considered as it is corroborated in figure nº 10. The X and Y axes gather the revised total effect of Europe and Spain, respectively, and the reference lines are constituted around the means revised total effects of each territory. Sectors such as Office and data processing machines (8), Other manufacturing products

(15), Building and construction (16), Lodging and catering services (18) and Maritime and air transport services (20) drive the two economies. Other market services (24), Fuel and power products (2) and Recovery, repair services, wholesale, retail (17) show little relevance in their impacts on the economy because they have low revised total effects – effects under the mean.

Figure nº 10. Revised Total Effects



Source: Own elaboration from SIOT-95 and EUIOT-95.

However, both countries keep some differentiating features in their profile. So the weight of traditional metallurgic sectors continues to be outstanding in Spain and, in Europe the effect of high-medium technological sectors is larger than the national economy.

5. CONCLUSIONS

Given the Social Network Theory, it is possible to extend knowledge on regional production organisation by determining the key sectors for the development of the economy. With this aim in view, the present work proposes multilevel indicators. These measures not only describe industries with a strong influence on the expansion of other sectors in an economy but the immediacy and the transmission capacity of their impacts. The power of a sector is summed up in an index influence that represents the weight of the role of the final and intermediate demand. This approach offers an extended vision of the key sectors that overcomes some of the limitations of the typical applications of the Graph theory or Network analysis. The common starting point in these techniques is that the matrix of transactions flows is binarized. In this sense, a crucial point of criticisms pertains to the loss of valuable information during binarization (De Mesnard, 1995). Reintroducing quantitative information as we have made in this work can overcome this criticism (Holub et al., 1985; Schnabl, 1994).

From this methodology, Spain shows a performance very similar to that of the European Union with a construction sector pulling the economy and an essential industrial sector for the whole activity. The manufacturing sector reveals the basic differences between the two territories. Spain still shows a traditional structure with an important presence of the metallurgic sector due to its history, while Europe has a better relative position in the high technological segment. Other researchers as Cañada, 1994; Buesa, 1996; Velasco and Plaza, 2003 has pointed out similar conclusions about the role of industry in their studies.

On other hand, the tertiary sector presents a similar position in both economies. This feature seems to indicate an analogous tertiary development degree. Its increasing importance in modern economies (Miles, 1993) has given rise to a wide range of studies about its contribution to development and technological innovation (Andersen et. al., 2000; Antonelli, 2000 and Tomlinson, 2000). This fact stresses the change in the traditional weight of the manufacturing base to a new knowledge economy.

It is relevant to emphasize that those sectors with higher total effects show as well a high immediacy. This supposes that serious barriers to the propagation of the impact of the key sectors do not exist and that the said impacts can be transmitted quickly to other sectors. In their propagation there are many significant industries that act as cross-roads in the network. It is a characteristic of developed economies that the productive structure has a complex network of essential linkages for its full vertebration.

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7. APPENDIX

Table 1. Correspondence between TIOEU and TIOE

Sectors TIOEU-95	Correspondence TIOE-95
1. Agriculture, forestry and fishery products	01+02+05
2. Fuel and power products	10+11+12+23+401+402+403+41
3. Ferrous and non-ferrous ores and metals	13+27
4. Non-metallic mineral products	14+261+262++263+264+265+266+267+268
5. Chemical products	24
6. Metal products except machinery	28
7. Agricultural and industrial machinery	29
8. Office and data processing machines	30+33
9. Electrical goods	31+32
10. Transport equipment	34+35
11. Food, beverages, tobacco	151+152+154+155+156+157+158+159+16
12. Textiles and clothing, leather and footwear	17+18+19
13. Paper and printing products	21+22
14. Rubber and plastic products	25
15. Other manufacturing products	20+36
16. Building and construction	45
17. Recovery, repair services, wholesale, retail	50+51+52+37
18. Lodging and catering services	55
19. Inland transport services	601+602+603
20. Maritime and air transport services	61+62
21. Auxiliary transport services	63
22. Communication services	64
23. Services of credit, insurance institutions	66+67+65
24. Other market services	70+71+72+73+74+911+80(p)+85(p)+90(p)+ 92(p)+93
25. Non-market services	75+80(p)+85(p)+90(p)+912+913+92(p)+95

Source: Own elaboration from UEIOT-95 and SIOT-95.

Table nº 2. Multilivel Indicators. Spain

Sectors	Total effects	Immediate Effects	Mediative Effects
1. Agriculture, forestry and fishery products	0,038	0,032	0,441
2. Fuel and power products	0,018	0,019	0,314
3. Ferrous and non-ferrous ores and metals	0,047	0,047	0,539
4. Non-metallic mineral products	0,052	0,056	0,584
5. Chemical products	0,037	0,039	0,496
6. Metal products except machinery	0,057	0,057	0,586
7. Agricultural and industrial machinery	0,045	0,047	0,541
8. Office and data processing machines	0,028	0,030	0,422
9. Electrical goods	0,034	0,036	0,472
10. Transport equipment	0,037	0,040	0,500
11. Food, beverages, tobacco	0,054	0,048	0,546
12. Textiles and clothing, leather, footwear	0,025	0,026	0,392
13. Paper and printing products	0,029	0,030	0,431
14. Rubber and plastic products	0,028	0,030	0,426
15. Other manufacturing products	0,039	0,042	0,512
16. Building and construction	0,074	0,080	0,669
17. Recovery, repair services, wholesale, retail	0,046	0,049	0,552
18. Lodging and catering services	0,050	0,057	0,585
19. Inland transport services	0,046	0,049	0,552
20. Maritime and air transport services	0,056	0,056	0,583
21. Auxiliary transport services	0,073	0,075	0,652
22. Communication services	0,014	0,015	0,265
23. Services of credit, insurance institutions	0,021	0,023	0,357
24. Other market services	0,051	0,055	0,580
25. Non-market services	0,042	0,043	0,500
Mean	0,042	0,043	0,500
First quartile	0,029	0,030	0,431
Third quartile	0,051	0,055	0,58

Source: Own elaboration from SIOT-95.

Table nº 3. Multilivel Indicators. Europe

Sectors	Total effects	Immediate Effects	Mediative Effects
1. Agriculture, forestry and fishery products	0,038	0,033	0,450
2. Fuel and power products	0,023	0,025	0,376
3. Ferrous and non-ferrous ores and metals	0,04	0,043	0,518
4. Non-metallic mineral products	0,036	0,039	0,494
5. Chemical products	0,032	0,034	0,461
6. Metal products except machinery	0,044	0,046	0,538
7. Agricultural and industrial machinery	0,050	0,053	0,574
8. Office and data processing machines	0,045	0,046	0,539
9. Electrical goods	0,049	0,05	0,560
10. Transport equipment	0,058	0,064	0,619
11. Food, beverages, tobacco	0,049	0,042	0,518
12. Textiles and clothing, leather, footwear	0,027	0,029	0,418
13. Paper and printing products	0,026	0,028	0,406
14. Rubber and plastic products	0,042	0,045	0,531
15. Other manufacturing products	0,041	0,044	0,532
16. Building and construction	0,057	0,062	0,617
17. Recovery, repair services, wholesale, retail	0,030	0,033	0,449
18. Lodging and catering services	0,043	0,048	0,550
19. Inland transport services	0,040	0,042	0,516
20. Maritime and air transport services	0,061	0,061	0,605
21. Auxiliary transport services	0,062	0,060	0,609
22. Communication services	0,022	0,023	0,362
23. Services of credit, insurance institutions	0,021	0,023	0,358
24. Other market services	0,026	0,028	0,411
25. Non-market services	0,036	0,038	0,491
Mean	0,039	0,042	0,500
First quartile	0,030	0,033	0,449
Third quartile	0,049	0,048	0,550

Source: Own elaboration from UEIOT-95.

Table nº 4. Influence index[x]

Sectors	Spain	Europe
1. Agriculture, forestry and fishery products	0,284	0,315
2. Fuel and power products	0,386	0,509
3. Ferrous and non-ferrous ores and metals	0,296	0,400
4. Non-metallic mineral products	0,230	0,284
5. Chemical products	0,248	0,456
6. Metal products except machinery	0,283	0,334
7. Agricultural and industrial machinery	0,173	0,242
8. Office and data processing machines	0,004	0,126
9. Electrical goods	0,142	0,294
10. Transport equipment	0,153	0,246
11. Food, beverages, tobacco	0,348	0,329
12. Textiles and clothing, leather, footwear	0,244	0,246
13. Paper and printing products	0,275	0,350
14. Rubber and plastic products	0,209	0,276
15. Other manufacturing products	0,187	0,191
16. Building and construction	0,239	0,191
17. Recovery, repair services, wholesale, retail	0,399	0,520
18. Lodging and catering services	0,129	0,117
19. Inland transport services	0,333	0,279
20. Maritime and air transport services	0,065	0,126
21. Auxiliary transport services	0,269	0,279
22. Communication services	0,137	0,191
23. Services of credit, insurance institutions	0,448	0,492
24. Other market services	0,512	0,697
25. Non-market services		0,193
Mean	0,250	0,307
First quartile	0,168	0,193
Third quartile	0,305	0,350

Source: Own elaboration from UEIOT-95 and SIOT-95.

Table nº 5. Revised Total Effects

Sectors	Spain	Europe
1. Agriculture, forestry and fishery products	0,038	0,040
2. Fuel and power products	0,029	0,025
3. Ferrous and non-ferrous ores and metals	0,038	0,038
4. Non-metallic mineral products	0,045	0,042
5. Chemical products	0,039	0,032
6. Metal products except machinery	0,040	0,038
7. Agricultural and industrial machinery	0,042	0,046
8. Office and data processing machines	0,046	0,052
9. Electrical goods	0,043	0,042
10. Transport equipment	0,043	0,049
11. Food, beverages, tobacco	0,040	0,042
12. Textiles and clothing, leather, footwear	0,043	0,047
13. Paper and printing products	0,040	0,037
14. Rubber and plastic products	0,040	0,042
15. Other manufacturing products	0,046	0,049
16. Building and construction	0,048	0,047
17. Recovery, repair services, wholesale, retail	0,030	0,024
18. Lodging and catering services	0,048	0,049
19. Inland transport services	0,034	0,038
20. Maritime and air transport services	0,048	0,051
21. Auxiliary transport services	0,039	0,041
22. Communication services	0,038	0,038
23. Services of credit, insurance institutions	0,040	0,033
24. Other market services	0,023	0,014
25. Non-market services		0,042
Mean	0,040	0,040
First quartile	0,038	0,038
Third quartile	0,044	0,047

Source: Own elaboration from UEIOT-95 and SIOT-95.

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[i] For a review of different methods see Sonis et al. (1995), Miller and Lahr (2001), Lenzen (2003) or Robles and Sanjuán (2005).

[ii] The centrality concept has been studied for a long time. The term has many definitions (Harary, 1965; Freeman, 1979) and different measures have been proposed for its measurement (centrality indexes).

[iii] A first approach in the development of these indicators in the input-output field has been published in García and Ramos (2003) and García, Morillas and Ramos (2005).

[iv] See the homogenisation table in the appendix where our homogenous aggregation is shown.

[v] Given an arbitrary term of power serial $\alpha^k \tilde{\mathbf{A}}^k$, if all non null entries of the input-output coefficients matrix $\tilde{\mathbf{A}}$ are represented by a unit value, the entry correspond in $\tilde{\mathbf{A}}^k = \{\tilde{a}_{ij}^k\}$ would indicate the paths number of length k between sector *i*th and *j*th.

[vi] See a first approximation to an empirical comparison between the proposed methodology and traditional input-output indicators –Rasmussen and Chenery-Watanabe- in García and Ramos (2003).

[vii] The results have been worked out using the network program Netminer (http://www.netminer.com).

[viii] Electrical goods (12,9%), Food, beverages, tobacco (11,9%), Mechanical fabrication (10,9%).

[ix] See Bluestone (1984) and Velasco & Plaza (2003), among others.

[x] The sector Non-market services has not included in the calculus for the Spanish economy because its relation absence with other sectors is a condition under which the Markov Chain will not have stationary state. Its not consideration do not disturb the relative sectorial position as its impact is null.